#### UNCLASSIFIED

## AD NUMBER AD003750 **NEW LIMITATION CHANGE** TO Approved for public release, distribution unlimited **FROM** Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; FEB 1953. Other requests shall be referred to Office of Naval Research, 800 North Quincy Street, Arlington, VA 22217-5660. **AUTHORITY** ONR ltr., 9 Nov 1977

Reproduced by Irmed Services Technical Information Agence DOCUMENT SERVICE CENTER

Best Available Copy

# INCI ASSIFIFE

## Columbia University in the City of New York

DEPARTMENT OF CIVIL ENGINEERING



# REFLECTION OF FLEXURAL WAVES AT THE EDGE OF A PLATE

By
T. R. KANE

Office of Naval Research Project NR-064-388

Contract Nonr-266(09)
Technical Report No. 6
CU-7-53-ONR-266(09)-CE
February 1953

#### ABSTRACT

The reflection of straight-crested flamural waves at the edge of a semi-infinite plate is studied in terms of a two-dimensional plate theory. It is found that, in general, a flexural wave propagated toward the edge at an arbitrary angle of incidence gives rise to three reflected waves: two flexural waves and a shear wave. A number of special cases, involving degenerate forms of these motions, are investigated in detail.

#### 1. Introduction

In this paper Mindlin's [1] equations of flexural motions of plates are used to study the reflection of a straight-created wave at the edge of a semi-infinite plate. The equations accommodate three modes of motion: two types of flexural waves and a thickness-shear wave. It is found that, in general, all three of these motions are excited upon incidence of any one of them at a free edge. The shear motion, here encountered, is of particular interest; for this motion is absent in the classical theory of plates, whence the applicability of that theory is restricted to a range of frequencies considerably below that corresponding to the first mode of thickness-shear wibration. By the same token, the present theory does not include the higher modes of motion which are to be found in three-dimensional elasticity theory; thus, the adjustion set forth below may be expected to furnish an adequate description for frequencies which do not materially exceed that of the first thickness-shear mode.

The character of the reflected waves is affected by both the angle of incidence and the ratio of plate thickness to wave-length of the incident wave. Appropriate values of these two parameters give rise to such special cases as waves whose amplitudes decrease exponentially with distance from the edge, vibrations, resonance, disappearance of some of the reflected waves, and, for grazing incidence, complete disappearance of the motion.

Following a resume of the plate equations in Section 2, straight-crested waves are considered in Section 3. Incident and emergent waves are described in Section 4 and, in terms of these, a formal solution is reached in Section 5. In Sections 6 and 7 various cases of normal and oblique incidence are discussed in detail. Section 8 deals with grazing incidence.

<sup>1.</sup> Numbers in brackets refer to the Bibliography at the end of the paper.

#### 2. Plate Displacements. Equations of Motion and Stresses

For a plate of thickness h , oriented as in Fig. 1, plate displacements  $\frac{1}{2}(x,y,t)$ ,  $\frac{1}{2}(x,y,t)$  and  $\frac{1}{2}(x,y,t)$  are given by (see [1])

$$\frac{1}{4} = \left[ (r_{1} - 1) \frac{\partial w}{\partial x} + (r_{2} - 1) \frac{\partial w}{\partial x} + \frac{\partial u}{\partial y} \right] e^{ipt} \\
 \frac{1}{4} = \left[ (r_{1} - 1) \frac{\partial w}{\partial y} + (r_{2} - 1) \frac{\partial w}{\partial y} - \frac{\partial u}{\partial x} \right] e^{ipt} \\
 \frac{1}{4} = \left[ (w_{1} + w_{2}) e^{ipt} + (r_{2} - 1) \frac{\partial w}{\partial y} - \frac{\partial u}{\partial x} \right] e^{ipt}$$
(1)

The functions  $W_i(x,y)$ ,  $W_i(x,y)$  and H(x,y) are governed, respectively, by equations of motion

$$(\vec{p} + \vec{s}, \vec{r}) w_{i} = 0$$

$$(\vec{p} + \vec{s}, \vec{r}) w_{i} = 0$$

$$(\vec{p} + \vec{s}, \vec{r}) H = 0$$
(2)

In the above,

Service of the service of the County of the service of the service

$$2(\delta_{i}^{2}\delta_{i}^{3}) = \delta_{0}^{4} \left\{ 5 + R \pm \left[ (5 - R)^{3} + 4\delta_{0}^{-4} \right]^{4} \right\}$$
(3)

$$(1-\mu)\omega^2 = 2(R5^{\circ} - 5^{-1}) \tag{4}$$

$$\mathcal{D}_{0}^{f} = \rho \rho^{k} h \tag{5}$$

$$R = \frac{h^2}{\sqrt{2}}, \quad S = \frac{D}{\sqrt{2}}$$

$$O = \frac{Eh^3}{\sqrt{2}(1-v^3)}, \quad (6)$$

p is the circular frequency associated with the wave motion.  $\mathcal{L}, \mathcal{F}, \mathcal{C}$  are, respectively, Young's Modulus, Poisson's Ratio, and the mass density of the plate material.

Plate bending moments  $\mathcal{M}_x$ ,  $\mathcal{M}_y$ , shears  $\mathcal{Q}_x$ ,  $\mathcal{Q}_y$  and twisting moment  $\mathcal{M}_{yx}$  are given by

$$M_{x} = D(3\frac{\pi}{2} + \nu 3\frac{\pi}{2})$$

$$M_{y} = D(3\frac{\pi}{2} + \nu 3\frac{\pi}{2})$$

$$2M_{yx} = D(1-\nu)(3\frac{\pi}{2} + 3\frac{\pi}{2})$$

$$Q_{y} = \kappa_{y}^{2} \kappa_{y}^{2} (2\frac{\pi}{2} + 3\frac{\pi}{2})$$

 $\mu$  is the modulus of rigidity of the plate material. The definition of  $\kappa^{k}$  is given in [1].

#### 3. Straight-Created Waves

Taking any one of the functions  $w_i, w_i$ , or H to be of the form  $A \exp(i \xi x)$ ,  $\xi > 0$ 

and letting the remaining two vanish identically, we find that, in each case, two of the equations of motion are automatically satisfied while the remaining

one requires that

Letting

this leads to [see Equations (3), (4), (5)] three possible types of relationships between phase velocity C and wave number f:

$$\frac{\mathcal{E}}{\partial s} = \begin{cases}
\frac{\Gamma - (\Gamma^{2} - 4s^{2}R5)^{\frac{N_{2}}{2}}}{2R}, & w_{1} \neq 0, & w_{2} = H = 0 \\
\frac{K}{\partial s} = \frac{K}{\delta} \left[ \frac{\Gamma + (\Gamma^{2} - 4s^{2}R5)^{\frac{N_{2}}{2}}}{2R} \right]^{\frac{N_{2}}{2}}, & w_{2} \neq 0, & w_{3} = H = 0 \\
\frac{K}{\delta} \left[ \frac{2 + s^{2}(1 - \nu)5}{R} \right]^{\frac{N_{2}}{2}}, & H \neq 0, & w_{3} = w_{2} = 0
\end{cases} \tag{9}$$

where

and  $C_3$  is the velocity of shear waves in an infinite medium. A plot of  $C_2$  versus  $h_{\mathcal{L}}$  (with  $y_{-1}/4$ ) for each of these cases is shown in Fig. 3. It is seen that  $C_2/C_3 \rightarrow 0$  as  $h_{\mathcal{L}} \rightarrow 0$  for a  $W_1$  wave, while  $C_2/C_3 \rightarrow \infty$  as  $h_{\mathcal{L}} \rightarrow 0$  for  $W_2$  and  $H_1$  waves. In the sequel we shall call  $W_1$  a "slow" flexural wave,  $W_2$  a "fast" flexural wave and  $H_2$  a shear wave. (The fact that the preceding discussion involves waves propagated in the  $X_1$ -direction, does not result in any loss of generality.)

#### 4. Incident and Emergent Waves

Referring the semi-infinite plate to axes  $x, y, \ge$  as shown in Fig. 2 we consider a slow flexural wave propagated towards the edge of the plate,

$$w_{i} = Ae^{i\varphi} \psi \qquad (10)$$

where

We postulate three amorgant waves, propagated respectively towards  $P'_{,}P''_{,}P'''$  as shown in Fig. 2. These are

a) a slow flexural wave:

$$w_1' = A'_{\ell} \dot{c} c' g''$$
,  $w_{\ell}' = H'_{\ell} = 0$  (11)

b) a fast flexural wave:

$$W_{2}^{"} = A^{"} e^{ig^{*}\psi^{*}}, \quad W_{1}^{"} = H^{2} = 0$$
 (12)

c) a shear wave:

$$H'' = A'' e^{i v'' p'''} w_1'' = w_2'' = 0$$
 (13)

eretty

and the  $\alpha^{j}$  are the angles of emergence shown in Fig. 2.

In accordance with Equations (9), these waves are propagated with velocities  $C^{J}$  which depend on their respective wave numbers  $c^{J}$ .

<sup>2.</sup> The case of a fast incident wave is similar in nature and will not be discussed in the present paper.

The displacements corresponding to these waves are obtained from Equation (1). Denoting the incident wave by  $w_j \not = and \not= and = an$ 

$$w^* = w + \sum_{i} w^{i}$$

$$Y_{x}^{*} = Y_{x} + \sum_{i} Y_{i}^{i}$$

$$Y_{y}^{*} = Y_{y} + \sum_{i} Y_{i}^{i}$$

$$(14)$$

のでは、これのでは、これのでは、これでは、これできないできない。 「これのできない。 「これのできない。 「これのできない。 「これのできない。 「これのできない。 「これのできない。」「これのできない。 「これのできない。」」「これのできない。」」「これのでき

is a possible state of motion for an infinite plate. For the semi-infinite plate under consideration, three boundary conditions must be satisfied on the edge X=0.

#### 5. Boundary Conditions

Plate stresses  $\mathcal{N}_{\chi}^{*}$ ,  $\mathcal{N}_{\gamma}^{*}$ , etc. corresponding to the motion defined by Equations (14) may be computed from Equations (7). To obtain a traction-free edge, we must have, on  $\chi=0$ ,

$$\mathcal{M}_{x}^{*} = \mathcal{M}_{yx}^{*} = \mathcal{Q}_{y}^{*} = 0. \tag{15}$$

In order that these equations be satisfied for all values of the time t and all values of the space variable y, it is necessary that the circular frequencies p and p associated with the various waves be identical, i.e.,

$$ye = y^{j}e^{j}, (16)$$

and that the angles  $\infty$  and  $\infty^j$  satisfy

$$f \sin \alpha = g^{2} \sin \alpha^{2}$$
. (17)

Now, the relation between C and g is of the same form as that between C' and g', both being slow flaxural waves. Thus it follows from Equations (16) and (17) that the angle of emergence  $\alpha'$  of the slow flaxural wave is equal to the angle of incidence  $\alpha'$  of the incident wave, and that the wave numbers and phase velocities of these two waves are identical. Equations (16) and (17) show, furthermore, that the condition of vanishing traction at the edge of the plate, [Eq. (15)], leads to a determination of the phase velocity, wave number and angle of emergence of each of the postulated emergent waves when the argle of incidence and wave number (or phase velocity) of the incident wave are specified.

The boundary conditions (15) also impose restrictions on the amplitude ratios A/A. From Equations (10)-(13), (14) and (7) we get, upon substitution into Equations (15), a system of three non-honogeneous linear algebraic equations governing these amplitude ratios,

$$\sum_{n} \phi_{n}^{j} A_{n}^{j} = -\frac{2}{3} \phi_{n}^{j} \cos[(2n-1)\pi], \quad j = j, \quad j =$$

where

with

$$M^{j} = 55_{0}^{4} - (g^{j})^{2}$$

$$\Theta^{j} = \cos^{3}\alpha i + y \sin^{3}\alpha i.$$

The analog, in the present theory, to F. Neumann's uniqueness theorem [2] guarantees that the above constitutes the unique solution of the problem. We may say then that a slow incident flexural wave produces, in general, three reflected waves: a slow flexural, a fast flexural, and a shear wave.

#### 6. Normal Incidence

We now proceed to study the character of the reflected waves in terms of the angle of incidence  $\propto$  and the wave number  $\rho$  of the incident wave. We begin by examining the case of normal incidence, i.e.,  $\propto = 0$ .

The wave numbers g'' and g''' of the fast reflected wave and of the shear wave are given by [see Eqs. (8), (4), (5)]

$$24^{4} = 5 \left\{ 5 + R - \left[ (5 - R)^{2} + 45^{4} \right]^{4} \right\}$$
 (20)

$$(y'')^2 = 2(1-y)^{-1}(RS_0^4 - S^{-1})$$
 (21)

Both f'' and f''' vanish when  $RSS_0^+=/$ , i.e., when f''RS=R+S. For f''RS<R+S, f'' and f''' are imaginary while for f''RS>R+S both are real. The physical significance of f''RS=/ will be discussed when the motion corresponding to that value of the wave number of the incident wave has been determined. We first consider

From Eq. (17) we have, for  $\propto = O_1$ 

The amplitude ratios are found from Eqs. (18):

$$\frac{A}{A} = \frac{a}{A} + \frac{b}{A}$$

$$\frac{A}{A} = \frac{a}{A} + \frac{b}{A}$$

$$\frac{A}{A} = 0$$
(22)

where

$$\frac{Q_{1}}{A} = \frac{(3^{n})^{2}(S_{0}^{n} + \bar{x}^{n})^{2} - x^{2}(S_{0}^{n} - x^{n})^{2}}{(\bar{x}^{n})^{2}(S_{0}^{n} + \bar{x}^{n})^{2} + x^{2}(S_{0}^{n} - x^{n})^{2}}$$

$$\frac{D_{1}}{A} = -\frac{2\bar{x}^{n}(S_{0}^{n} + \bar{x}^{n})^{2} + x^{2}(S_{0}^{n} - x^{n})^{2}}{(\bar{x}^{n})^{2}(S_{0}^{n} + \bar{x}^{n})^{2} + x^{2}(S_{0}^{n} - x^{n})^{2}}$$

$$\frac{Q_{1}}{A} = -\frac{2\bar{x}^{n}(S_{0}^{n} + \bar{x}^{n})^{2}(S_{0}^{n} + \bar{x}^{n})^{2} + x^{2}(S_{0}^{n} - x^{n})^{2}}{(\bar{x}^{n})^{2}(S_{0}^{n} + \bar{x}^{n})^{2} + x^{2}(S_{0}^{n} - x^{n})^{2}}$$

$$\frac{D_{1}}{A} = \frac{2\bar{x}^{n}(S_{0}^{n} + \bar{x}^{n})^{2} + x^{2}(S_{0}^{n} - x^{n})^{2}}{(\bar{x}^{n})^{2}(S_{0}^{n} + \bar{x}^{n})^{2} + x^{2}(S_{0}^{n} - x^{n})^{2}}$$

and

so that Z" is real.

The incident wave is given by [see Eqs. (1) and (10)]

$$W = A \cos f(x+ct)$$

$$W = -A M' f^{-1} \sin f(x+ct)$$

$$W = 0$$
(23)

The slow reflected wave [Eq. (11)] becomes

$$w' = A \cos y (x - ct + l,)$$
  
 $4x' = -AM'y^{-1} \sin y (x - ct + l,)$   
 $4y' = 0$ 

and the fast reflected wave [Eq. (12)] is given by

$$W'' = (a_{i}^{2} + b_{i}^{2})^{4} e^{-\bar{p}^{2}x} \cos(\varphi ct - \ell_{i})$$

$$Y_{x}^{n} = (\bar{p}^{n})^{-1} (5\delta_{0}^{n} - \bar{p}^{n})^{2} W''$$

$$Y_{y}^{n} = 0$$

In the above,

We see that the slow reflected wave has the same amplitude, wave-length and velocity as the incident wave, but is out of phase with it. The fast reflected "wave" is, in fact, a <u>vibration</u>, the amplitude of which decreases exponentially as the distance from the edge of the plate increases. As A''=0 by Eq. (22), no other waves are reflected.

Now consider

Equations (22) are then replaced by

$$\frac{A'}{A} = \frac{f''(SS_0^4 - g^{*}) + g(SS_0^4 - g^{*})}{f''(SS_0^4 - g^{*}) - g(SS_0^4 - g^{*})}$$

$$\frac{A''}{A} = \frac{2(SS_0^4 - g^{*})g''}{g(SS_0^4 - g^{*}) - f''(SS_0^4 - g^{*})}$$

$$\frac{A'''}{A} = 0$$

The incident wave remains unchanged [Equations (23)], the slow reflected wave becomes

$$w' = A' \cos_{\xi} (x - ct)$$

$$Y'_{x} = -A' M'_{\xi} e' \sin_{\xi} (x - ct)$$

$$Y'_{y} = 0,$$
(26)

the fast reflected wave is given by

$$W' = A'' \cos \xi''(x - c'' t)$$
 $Y'_{x} = A'' M''(\xi')'' \sin \xi''(x - c'' t)$ 
 $Y''_{y} = 0,$ 

(27)

and the reflected shear wave again vanishes. (The amplitude ratios A/A and A/A for this case are plotted versus  $h_{\mathcal{E}}$  in Fig. 4.)

The incident wave is seen to give rise to two reflected flexural waves; we may examine the manner in which the energy per unit length of wave-front, per cycle, of the incident wave is distributed to the two reflected waves. Using the expressions for energy given in Raference [4], we find

$$\frac{E'}{E} = \left(\frac{A'}{A}\right)^{2}$$

$$\frac{E'}{E} = \left(\frac{A''}{A}\right)^{2} \left(\frac{A''}{a}\right)^{2} \frac{\frac{1}{4}a^{2} + M^{2}}{60^{2} + M^{2}}$$

Here  $\mathcal{E}$ ,  $\mathcal{E}'$  and  $\mathcal{E}'$  are, respectively, the energy per cycle, per unit length of wave front of the incident wave, for the incident, slow reflected and fast reflected waves. The ratios  $\mathcal{E}'/\mathcal{E}$  and  $\mathcal{E}''/\mathcal{E}$  are plotted versus  $\mathcal{L}_{\mathcal{E}}$  in Fig. 5.

The motion corresponding to

may be found by proceeding to the limit, as  $g^2R5 \rightarrow R+5$ , in either of the preceding cases. By either method it may be verified that an incident wave

$$W = A cost(x+ct)$$

$$Y_y = A \sqrt{\frac{R}{s(R+s)}} sing(x+ct)$$

$$Y_y = 0$$
(28)

now gives rise to a slow reflected wave,

$$w' = -A \cos \varphi (x - ct)$$

$$Y'_{x} = -A \sqrt{\frac{R}{S(R+S)}} \sin \varphi (x - ct)$$

$$Y'_{y} = 0$$
(29)

and to a thickness-shear vibration,

the same and the s

$$W'' = 0$$

$$Y' = 2A \sqrt{\frac{5}{R(R+5)}} \text{ singet}$$

$$Y''_{4} = 0$$
(30)

The circular frequency p for this vibration is [see Eqs. (3), (5), (6), (8), (9)]

Now, the circular frequency,  $\overline{\rho}$ , of the first antisymmetric mode of thickness-shear vibration of an infinite plate, according to the three-dimensional theory

of elasticity, is

Thus it seems appropriate to let

so that the thickness-shear vibration in the present case will occur at the frequency predicted by exact theory for an infinite plate of the same thickness.

It is interesting to notice that the motion here being considered, is one of the possible modes of motion of an infinite strip of thickness h and width b (see Reference [3]), provided

Hence, for  $\sqrt{K}5 = R + 5$ , i.e., for  $p = \overline{p}$ , the semi-infinite plate may be regarded as consisting of an infinite number of independently vibrating strips, each with its infinite dimension parallel to the edge of the plate.

To conclude the discussion of normal incidence, we consider two limiting cases:

when the wave-length of the incident wave is large in comparison with the thickness of the plate, we find, by proceeding to the limit in Equations (22)-(25), as  $hy \rightarrow 0$ ,

$$w' = -A \sin y (x-ct)$$

$$y' = -A \cos y (x-ct)$$

$$y' = 0$$

$$w'' = A e^{-tx} (\cos y ct + \sin y ct)$$

$$y'' = -A e^{-tx} (\cos y ct + \sin y ct)$$

$$y'' = 0$$

$$w''' = 0$$

$$y''' = 0$$

$$y''' = 0$$

These expressions show that the incident wave is reflected without change in amplitude or phase velocity, and that a vibration, confined primarily to a region near the edge of the plate, takes place. The classical theory of plates (whose range of applicability is restricted to the limiting case under consideration) predicts the same results.

For wave-lengths which are very small in comparison with the plate thickness, we let  $h_{\mathcal{F}}$  approach infinity in Equations (26), (27) with the result

<sup>3.</sup> The theory is not expected to be good for very short waves. This limiting case is included for the cake of completeness.

The total motion is

which is a standing wave.

#### 7. Oblique Incidence

We have seen that fundamentally different states of motion obtain according as the circular frequency of the incident wave is less than, equal to, or greater than the circular frequency of thickness-shear vibration of an infinite plate. Hence, for  $0 < \varkappa < \pi/2$  we shall again examine separately the cases  $p < \bar{p}$ ,  $p > \bar{p}$  and  $p = \bar{p}$ .

As  $\beta \ll \beta$  is equivalent to  $RSS_0 \ll /$ , we see from Equations (20) and (21) that  $\rho''$  and  $\rho'''$  are imaginary.

Setting

we get, from Equation (17),

whence

(For all values of  $\alpha$  and  $\beta$  we have, as noted earlier,  $\beta' = \beta$ , c' = c,  $\alpha' = \alpha$ .)

Substituting into the general expressions for the various reflected waves [Equations (11), (12), (13)], we get from Equations (1),

$$W'' = A' \exp(iy \hat{S} - \hat{F}'' m^* x)$$
 $Y_{x}'' = W'' M'' m''$ 

(31)

where

These expressions are valid for all  $\propto$  with the possible exception of  $\alpha = T/2$ , i.e., "grazing" incidence. For that case, the solution of Equations (18) is

and we get, in place of Equations (31),

so that the entire motion is then [see Eq. (14)]

$$w^* = y^* = y^* = 0. (32)$$

This complete disappearance of the motion is analogous to the case of grazing incidence in the reflection of plane waves from the plane boundary of a semi-infinite solid. We shall return to this question later on.

The waves described by Equations (31) are

- 1 a slow flexural wave, reflected at an angle equal to the angle of insidence of the insident wave,
- 2 a fast flexural wave of amplitude decreasing exponentially with departure from the edge, and propagated in a direction parallel to the edge,
  - 3 = a shear wave of exponentially decreasing amplitude, propagated along the edge. (See Fig. 6.)

.Turning now to the case

#### <u>ā < a</u>

we note that, from Equations (20) and (21)

(Fig. 8 illustrates these facts for -1/4.)

Equation (17) permits us to construct a table which shows the relationship between  $\propto$  and  $\propto'$ ,  $\propto''$ ,  $\propto'''$  in terms of trigonometric functions of these angles.

2 418   O # 17 618	# 0	итх <sup>*</sup> в с,	005~ * 1		
3 < 10 × < 7 /7 , 3 < 10 ×	Lete Horse	u• √ ° ~ 1 . ;	: < 554 × ′ ≤ 1 <sup>1</sup> 4	ונבק ב ונב מלבונה א'	0 4.0m × "< 1
tis x = 2'/   415 2'	* */%i	iin 💉 🕡 1	esi √ " = 0 <sub> </sub> i	125 / * 125 * * * * * * * * * * * * * * * * * * *	0 < 004 × ™ < 1
PLACEDIC CPTA PLACEDY					:<:::x '< i }
sing ages sing	1 = 5 j : < 1	iio× * ≠Z₹ =	con 😾 Law gr	ein ≪‴≡ 1	ເລເ≪້≢ 0
PRIDA C 1 PRIDA	- 1 :	وأدحك معا	ess N. Lung,	1 < 112 <	ecs ox issag.
110 X + 1   10 X		ito x ' e #/j o	oak imag. I	1 < 150 H" # #/4"	cos ∝ nast.

With the help of this table and Equations (10)-(13) we can now describe the motion associated with various angles of incidence.

For O≤ Sinx < \$"/f , the reflected waves are

- 1 a slow flexural wave,
- 2 a fast flexural wave,
- (3) a shear wave.

These emerge at angles  $\propto'$ ,  $\propto''$ ,  $\propto'''$  with

as shown in Fig. 7. For instance, with  $h_{\mathcal{G}} = 5$ , we have  $\theta''/\theta = .372$ ,  $\theta'''/\theta = .593$ . Taking  $\alpha = 15^{\circ}$  (so that  $\sin \alpha < .302$ ) we get

$$\alpha' = 15^{\circ}$$
 $\alpha'' = \text{arc sin } \frac{.259}{.302} = 59.1^{\circ}$ 
 $\alpha''' = \text{arc sin } \frac{.259}{.593} = 25.9^{\circ}$ 

For Since of , the amplitude ratios [see Eqs. (18)] are

$$\frac{A'}{A} = 1$$
,  $\frac{A''}{A} = \frac{2(5\delta_0^4 - y^2)}{\nu(5\delta_0^4 - y^{-1})} \left[ \left( \frac{y^n}{y} \right)^2 (1 - y^2) - 1 \right]$ ,  $\frac{A'''}{A} = 0$ .

Thus we have only two reflected waves, (see Fig. 9),

- 1 a slow flexural wave whose angle of emergence is equal to the angle of incidence of the incident wave,
  - (2) a fast flexural wave propagated along the free edge.

With  $A_{\perp}$  = 5, as in the numerical example above, the critical angle,  $\alpha_{\perp}$ , for which the shear wave vanishes, is

Letting  $\alpha$  increase further, until  $\theta'/\theta < \theta = \alpha < \theta'/\theta'$ , we find that the fast flexural wave [Equations (12)] changes in character since  $\cos \alpha''$  is now imaginary. The shear wave reappears and we have (Fig. 10)

- 1 a slow flexural wave,
- 2 an exponentially decaying tast flexural wave, propagated parallel to the edge.
- Another critical value of x is reached when sinx. We then find (Fig. 11)
- a slow flexural wave,
  - 2 · an exponentially decaying fast flexural wave,
  - 3 s shear wave.

Both and are now propagated along the edge. With  $h_{g} = 5$ , the critical value for  $\alpha$  is 36.4.

Finally, for  $J''/J < Sin \propto < /$ , the shear wave also acquires an exponentially decaying amplitude, giving us (Fig. 12)

- 1 a slow flexural wave,
- 2 an exponentially decaying fast flexural wave,
- 3 an exponentially decaying shear wave.

Grazing incidence, i.e.,  $\alpha = 90^{\circ}$ , leads to vanishing motion, as it did for  $P < \bar{P}$ .

To complete the discussion of oblique incidence, we consider the case

As the circular frequency of the incident wave approaches the thickness-shear frequency, the amplitudes of the fast reflected wave and of the reflected shear wave become infinite. The resonance encountered here is due to the fact that reflection at the edge of the plate is equivalent to "forcing" the plate at a frequency equal to a "natural" frequency. For, it may easily be verified that the vibration

is a motion which satisfies the equations of motion (2) and leaves the edge X=0 free of traction:

#### 8. Grasine Incidence

We have seen [Eq. (32)] that the wave motion in a semi-infinite plate disappears as the angle of incidence approaches 90°. A similar situation obtains in the case of waves reflected from the plane boundary of a semi-infinite solid. By application of a suitable limiting process, wave motions for the latter case have recently been found by Goodier and Bishop [4]. A similar limiting process for the present case will now be considered.

Letting

and neglecting higher powers of  $\epsilon$ , we have, from Equations (17),

Substituting into Equations (18), the amplitude ratios are found to be of the form

$$\frac{A'}{A} = -(1+a'\epsilon), \quad \frac{A''}{A} = a'\epsilon, \quad \frac{A'''}{A} = a'''\epsilon$$
(33)

Expanding the exponentials which appear in the expressions for displacements, we get from Equations (10)-(13) and Equation (1),

$$W = A(1-iyex) \exp(iye)$$

$$W' = A'(1+iyex) \exp(iye)$$

$$W'' = A'' \exp(ige - xf'')$$

$$H''' = A''' \exp(igy - xf''')$$
(34)

vnere

These expansions are valid only when higher powers of wex can be neglected; that is, for a range of distances from the edge which is small in comparison with the wave-length of the incident wave.

From Equations (14), (32) and (34), the total motion is characterized by the expressions

$$W = A \in [-\alpha' - 2igx + \alpha' - \frac{f^*x}{2}] \exp(ig - \frac{f^*x}{2})$$
 (35)

$$H'' = A \in a'' \exp(igy - xf'''). \tag{36}$$

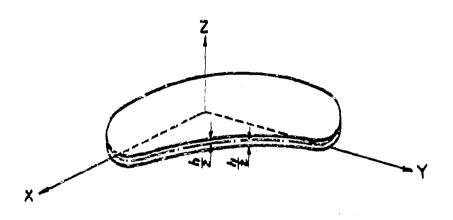
If we now permit A to become infinite as  $\epsilon$  approaches zero, and let the approach to infinity be such that the product  $A\epsilon$  remains finite, we see that the first term of Equation (35) represents an incident flexural wave while the second term corresponds to the " $P_{\mu}$ " wave found by Goodier and Bishop. The third term and Equation (36) indicate, respectively, a flexural and a shear wave, each propagated along the edge of the plate, and each having an exponentially increasing or decreasing amplitude, according as p is less than or greater than p; for p = p we again have resonance.

#### Adknowledgment

The author wishes to thank Professor R. D. Mindlin of Columbia
University both for suggesting this problem, and for his helpful advice
in life solution.

#### Hibliography

- T. R. D. Mindlin, "Influence of Rotatory Inertia and Shear on Flexural Motions of Isotropic, Elastic Flates," Journal of Applied Mechanics, Vol. 18 (1951), pp. 31-38.
- 2. A. E. H. Love, Theory of Elasticity, (Cambridge University Press, London, 1927), 4th Ed., p. 176.
- 3. R. D. Mindlin, "Thickness-Shear and Flexural Vibrations of Crystal Flater," Journal of Applied Physics, Vol. 22 (1951), pp. 316-323.
- 4. J. N. Goodier and R. E. D. Mishop, "A Note on Critical Reflections of Elastic Waves at Free Surfaces," Journal of Applied Physics, Vol. 23 (1952), pp. 124-126.



Mg. 1

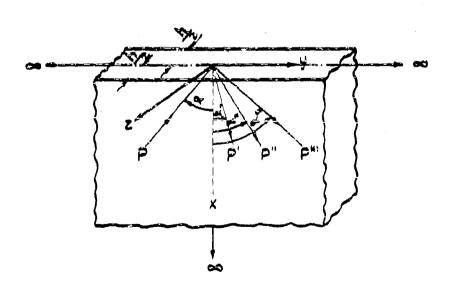


Fig. 2: Incident and Emergent Wave Normals.

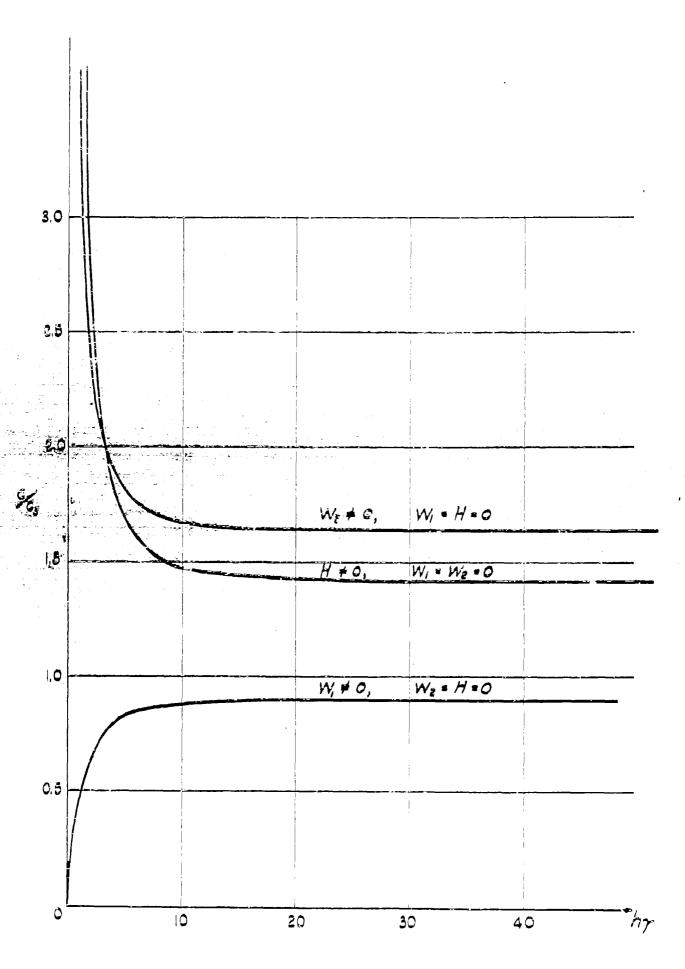
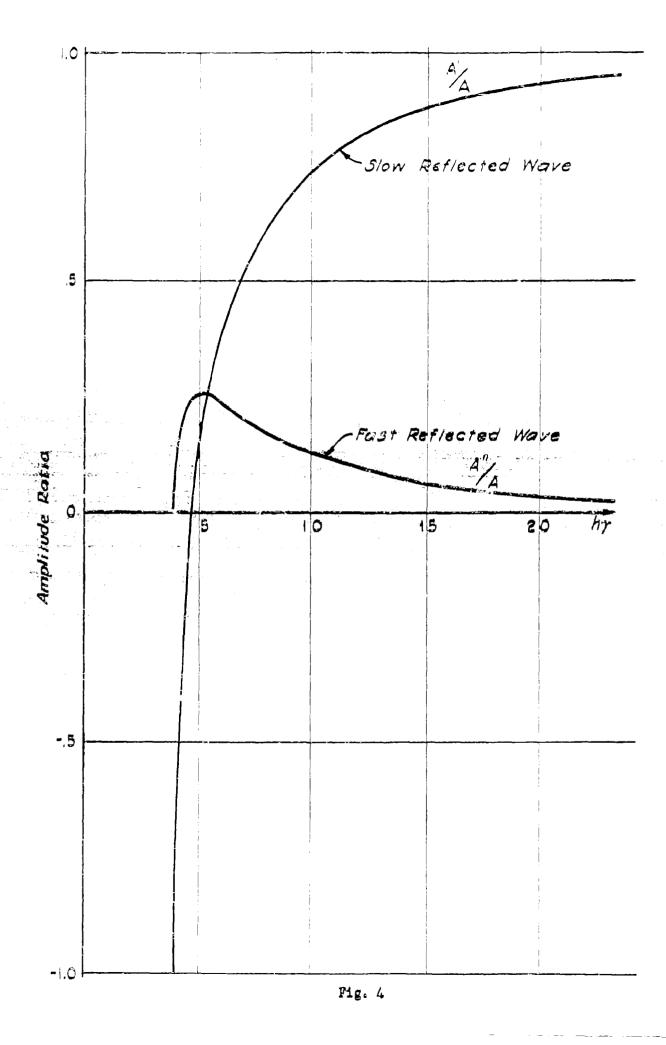


Fig. 3: Relationship between Phase Velocity and Wave Number.



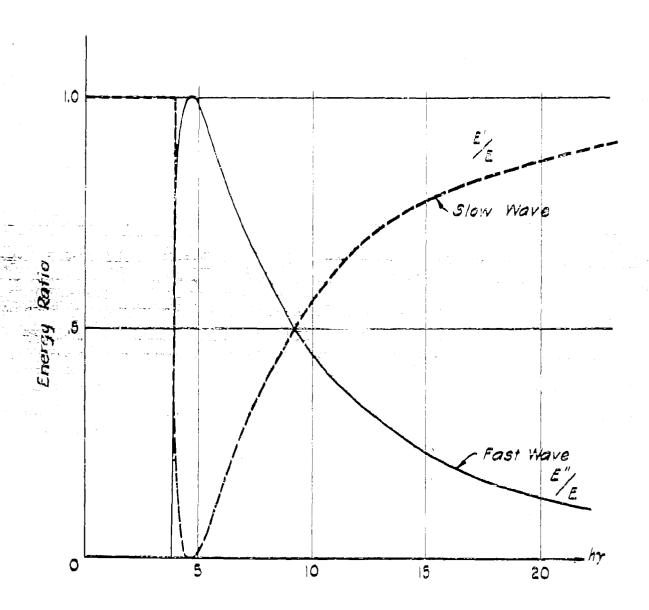


Fig. 5: Energy Partition - Normal Incidence.

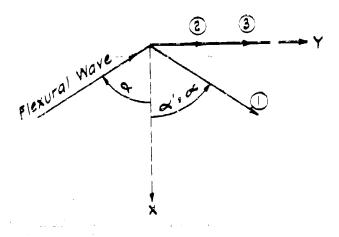


Fig. 6: Oblique Incidence,  $\rho < \bar{\rho}$ .

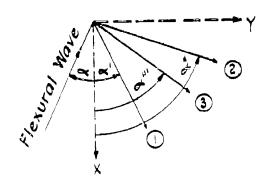


Fig. 7: Oblique Incidence,  $p > \overline{p}$ ,  $0 \le \sin \alpha < r^{n}/r$ .

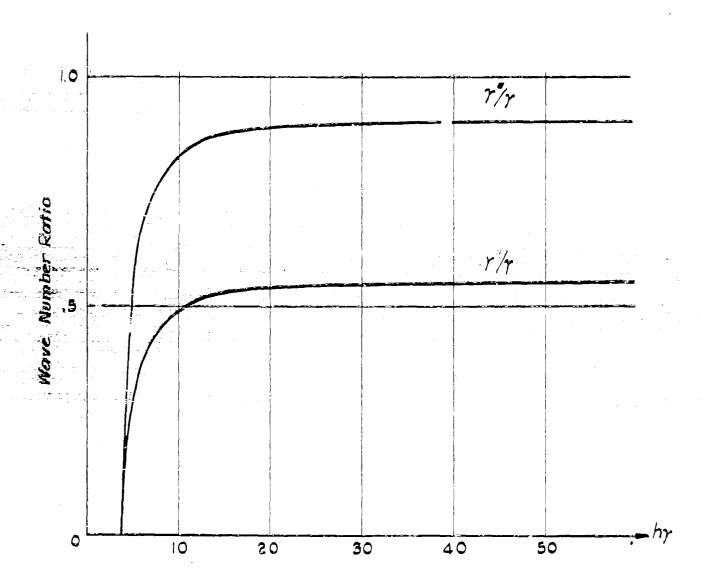


Fig. 8: Wave Number Ratios.

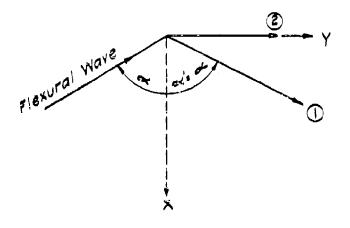


Fig. 9: Oblique Incidence, p>p, sina=Y//.

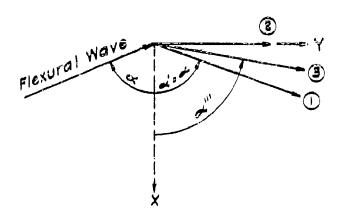
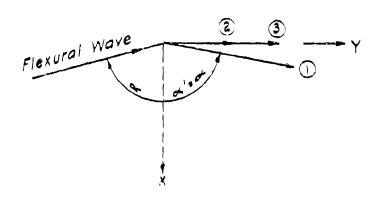


Fig. 10: Oblique Incidence, p>p, p///< sim< r"//.



. . .

Fig. 11: Oblique Incidence,  $p > \overline{p}$ ,  $s/n\alpha = Y^{\overline{p}}/Y$ .

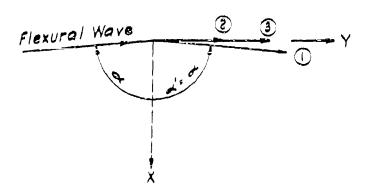


Fig. 12: Oblique Incidence,  $p > \bar{p}, \gamma''/\gamma < \sin \alpha < 1$ .

#### DISTRIBUTION LIST

#### for

Technical and Final Reports Issued Under Office of Naval Research Project NR-064-388. Contract Nonr-266(09)

#### Administrative. Reference and Lisison activities of ONR

Commanding Officer

Chief of Naval Rasearch

Department of the Navy Washington 25, D.C. Attn: Code 438	(2)	Office of Naval Research Branch Office 1000 Geary Street	(1)
Director, Naval Research Lab. Washington 25, D.C. Attn: Tech. Infc. Officer Technical Library Mechanics Division Code 3834 (J. P. Walsh)	(9) (1) (2) (1)	San Francisco 24, California  Commanding Officer  Office of Naval Research  Branch Office  1030 Green Street  Pasadena, California	(1)
Commanding Officer Office of Naval Research Branch Office 150 Causeway Street Boston 10, Massachusetts	(1)	Contract Administrator, SE Area Office of Naval Research o/o George Washington University 707 22nd Street, N.W. Washington 6, D.C.	(1)
Commanding Officer Office of Naval Research Branch Office 346 Breadway New York 13, New York	(1)	Officer in Charge Office of Navel Research Branch Office, London Navy No. 100 FPO, New York, N.Y.	(5)
Commanding Officer Office of Naval Research Branch Office 844 N. Rush Street Chicago 11, Illinois	(1)	Library of Congress Washington 25, D.C. Attn: Navy Research Section	(2)
<u>Department</u> Other Interseted Co			
GENERAL	AAGT IRREIT O	GENERAL (cont.)	
Research and Development Board Department of Defense Fentagon Building Washington 25, D.C. Attn: Library (Code 3D-1075)	(1)	Joint Task Force 3 12 St. & Const. Ave., N.W. (Temp. Washington 25, D.C. Attn: Major B. D. Jones ARMY	U) (1)
Armed Forces Special Weapons Project P.C. Box 2610 Washington, D.C. Attn: Col. G. F. Blunda	(1)	Chief of Staff Department of the Army Research and Development Division Washington 25, D.C. Atth: Chief of Res. and Dev.	(1)

ARMY (cont.)		ARMY (cont.)	
Office of the Chief of Engineers		Commanding Officer	
Assistant Chief for Works		Watertown Arsenal	
Department of the Army			
Bldg. T-7, Gravelly Point		Watertown, Massachusetts	/- 1
Waahington 25, D.C.		Attn: Laboratory Division	(1)
Attn: Structural Branch		Commanding Officer	
(R. L. Bloor)	(1)	Frankford Arsenal	
		Philadelphia, Pennsylvania	
Office of the Chief of Engineers		Attn: Laboratory Division	(1)
Asst. Chief for Military Construct	d on		\_ /
Department of the Army	244	Cammandina COOLage	
Bldg. T-7, Gravelly Point		Commanding Officer	
Washington 25, D.C.		Squier Signal Laboratory	
Address Charachisms Comment		Fort Monmouth, New Jersey	
Attn: Structures Branch	40.4	Attn: Components and Materials	
(H. F. Carey)	(1)	Branch	(1)
6 h h l l l l l l l l l l l l l l l l l		at a step	, ,
Office of the Chief of Engineers		NA VY	
Asst. Chief for Military Operation	8	Chief of Bureau of Ships	
Defartment of the Army		Navy Department	
Blug. T-7, Gravelly Point		Washington 25, D.C.	
Vallatington 25, D.C.		Hadithen Dimedian of Society	/= \
Attn: Structures Development Bran	ماد	Attn: Director of Research	(2)
(W. F. Woollard)		<b></b>	
(M) E. MOOTTWAD	(2)	Darector	
The call are street in the second of the sec		David Taylor Model Basin	
Engineering Research & Development	Lab.	Washington 7, D.C.	
Fort Belvoir, Virginia		Attn: Structural Mechanics Div.	(2)
Attn: Structures Branch	(1)		, ,
		Director	
The Commanding Ceneral		Naval Engr. Experiment Station	
Safaia Base, P.O. Box 5100		Annapolis, Maryland	(1)
Albuquerque, New Maxico		Windlested Light Atomic	(4)
Atth: Col. Canterbury	(1)	Manager and the second	
The state of the s	(4)	Mirector	
Americal seco Sanaamah Addi san		Materials Laboratory	
Operations Research Officer		New York Naval Shipyard	
Department of the Army		Brooklyn 1, New York	(1)
Ft. Lesley J. MoNair		• ,	
Washington 25, D.C.		Chief of Bureau, of Ordnance	
Atta: Howard Brackney	(1)	Navy Department	
•	,,	Washington 25, D.C.	
Office of Chief of Ordnance			(1)
Research & Development Service		Attn: Ad-3, Technical Library	(1)
Department of the Army		Superintendent	
The Fentagon		Naval Gun Factory	
Washington 25, D.C.		Washington 25, D.C.	(1)
Attn: ORDTB	(2)		
		Naval Ordnance Laboratory	
Commanding Officer		White Cak, Maryland	
Ballistic Research Laboratory		RFD 1, Silver Spring, Maryland	
Aberdeen Frowing Ground			(2)
Aberdeen, Maryland		Attn: Mechanies Division	(4)
	/11	V = 1 A.1	
Attn: Dr. C. W. Lempson	(1)	Naval Ordnance Test Station	
		Inyckern, California	
		Attn: Scientific Officer	(1)

では、「一般のでは、「「「「「」」」というでは、「「」」というできます。「「」」というでは、「「」」というできます。「「」」というできます。「「」」というできます。「「」」というできます。「「」」という

NAVX (cont.)		AIR FORCES (cont.)	
Naval Ordnance Test Station Underwater Ordnance Division Pasadena, California Attn: Structures Division	(1)	Office of Air Research Wright-Patterson Air Force Base Dayton, Chio Attn: Chief, Applied Mechanics	(a. )
Fhysics Livision	(1)	Group	(1)
Chief of Bureau of Aeronautics		OTHER GOVERNMENT AGENCIES	
Navy Department		U.S. Atomic Energy Commission	
Washington 25, D.C.		Division of Research	
Attn: TD-41, Technical Library	(1)	Washington, D.C.	(1)
Naval Air Experimental Station		Argonne National Laborator,	
Naval Air Materiel Center		P.O. Box 5207	/. 1
Naval Base		Chicago 80, Illinois	(1)
Philadelphia 12, Fennsylvania Attn: Head, Aeronautical Material	1.	Director	
Laboratory	(1)	National Rureau of Standards	
EEGG COO J	(= /	Washington, D.C.	
Chief of Bureau of Yards & Dooks		Attn: Dr. W. H. Ramberg	(1)
Navy Department			, ,
Washington 25, D.C.		U.S. Coast Guard	
Attn: Code P-314	(1)	1300 E Street, N.W.	
		Washington, D.C.	
Officer in Charge	_	Attn: Chief, Testing & Developme	ent
Naval Civil Engr. Research and En	al.	Division	(1)
laboratory		Charles & Charles & M. C. St. and A. 1994	
Naval Station	/a \	Forest Products Laboratory	
Port Hueneme, California	(1)	badison, Wisconsin Attn: L. J. Markwardt	(1)
Commoderandant II C Name T Dane		Worm: D. O. WHIEMSTAL	( 1
Superintendent, U.S. Naval Post Graduate School		National Advisory Committee for	
Annapolis, Maryland	(1)	Aeronautics	
Amapara, arrana	( <b>~</b> /	1724 F Street, N.W.	
Commander		Washington, D.C.	(1)
U.S. Naval Proving Grounds		, , , , , , , , , , , , , , , , , , , ,	, ,
Dahlgren, Virginia	(1)	National Advisory Committee for Aeronautics	
		langley Field, Virginia	
AIR FORCES		Attn: Dr. E. Lundquist	(1)
Commanding Ceneral			, ,
U.S. Air Forces		National Advisory Committee for	
The Fentagon		Aeronautics	
Washington 25, D.C.		Cleveland Municipal Airport	
Attn: Research & Development		Cleveland, Chio	<i>1</i> - 1
Division	(1)	Attn: J. H. Collins, Jr.	(1)
Cana indiang General		U.S. Maritime Commission	
Air Makeriel Command		Technical Bureau	
Wright-Patterson Air Force Base		Washington, D.C.	
Dayton, Chio		Attn: Mr. V. Russo	(1)
Attn: MCREX-B (E. H. Schwartz)	(1)		, ,

### Contractors and Other Investigators Actively Engaged in Related Research

University of Pennsylvania Professor Lynn Beedle Fritz Engineering Leboratory Lehigh University Esthlehen, Pennsylvania (1) Professor C. B. Biezeno Isohnische Hoogeschool Niewe Laan 76 Professor M. A. Biot ISIP Broedway New York, New York (1) Professor R. L. Bisplinghoff Messachusetts Institute of Technology Dept. of Aeronautical Engineering Columbia University New York 27, New York (1) Professor J. A. Bogdanoff Lurius University Leftyste, Indiana (1) Professor P. W. Bridgenan Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor P. W. Bridgenan Dept. of Civil Engineering Columbia University Columbia University Professor P. W. Bridgenan Dept. of Civil Engineering Columbia University Cambridge, Wassachusetts (1) Professor P. W. Bridgenan Dept. of Civil Engineering Columbia University Cambridge, Wassachusetts (1) Professor P. W. Bridgenan Dept. of Civil Engineering Columbia University C	Professor J. R. Andersen Towne School of Engineering		Dr. G. F. Carrier Graduate Division of Applied Math	ematics
Fritz Engineering Leboratory Lehigh University Bothlehem, Fennsylvania (1)  Professor C. B. diezeno Fadnische Hoogeschool Niewe Laan 76 Delft, Holland (1)  Professor M. A. Biot 1819 Broedway New York, New York Professor R. L. Bisplinghoff Wissachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts Columbia University New York 27, New York Professor J. A. Bogdanoff Lurdue University Lafayette, Indiana (1)  Professor F. W. Bridgenan Dept. of Civil Engineering Columbia University Lafayette, Indiana (1)  Professor F. W. Bridgenan Dept. of Civil Engineering Columbia University Lafayette, Indiana (1)  Professor J. M. Burmister Dept. of Civil Engineering Columbia University Lafayette, Indiana (1)  Professor F. W. Bridgenan Dept. of Civil Engineering Columbia University Cambridge Senter Chicago (1)  Professor J. M. Burmister Dept. of Civil Engineering Columbia University Cambridge Senter Chicago (1)  Professor J. M. Burmister Dept. of Civil Engineering Columbia University Cambridge Senter Chicago (1)  Professor J. M. Burmister Dept. of Civil Engineering Columbia University Cambridge Senter Chicago (1)  Professor J. M. Burmister Dept. of Civil Engineering Columbia University Cambridge 39, Massachusetts Chicago (1)  Professor J. J. Dolan Dept. of Theoretical and Applied Mechanics University of Illinois University of Illinois University of Illinois University Cambridge 39, Massachusetts University of Illinois University of Mechanics University of Illinois (1)  Professor J. J. Dolan Dept. of Civil Engineering Columbia University Columbia Cuniversity Columbia University Co		(1)		(1)
Lehtigh University Bethlehen, Fennsylvania (1)  Professor C. B. diezeno Teadnitsche Hoogeschool Niewe Lean 76 Delft, Holland (1)  Professor M. A. Biot 1819 Broedway New York, New York (1)  Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts (1)  Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University New York 27, New York (1)  Professor J. A. Bogdanoff Hurdus University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University Columbia University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University Columb				
Bothlehen, Fennsylvania (1)  Professor C. B. diezeno Tadhnische Hogeschool Niswe Laan 76 Delft, Holland (1)  Professor M. A. Biot 1819 Broadway New York, New York (1)  Professor R. L. Bisplinghoff Wissachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts (1)  Dr. Hans H. Bleich Dept. of Civil Ingineering Columbia University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University Columbia University Lafayette, Indiana (1)  Professor J. M. Bridgeman Dept. of Fhysics Earward University Columbia University Rew York 27, New Bridgeman Dept. of Civil Engineering Columbia University Rew York 27, New Hork  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Rew York 27, New Hork  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Rew York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Rew York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Rew York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Rew York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Rew York 27, New York  (1)  Professor D. C. Drucker Encome University Rew York 27, New York  (1)  Professor D. C. Drucker Encome University Rew York 27, New York  (1)  Professor D. C. Drucker Encome University Rew York 27, New York  (1)  Professor D. C. Drucker Encome University Rew York 27, New York  (1)  Professor D. C. Drucker Encome University Rew York 27, New York  (2)  Professor D. C. Drucker Encome University Rew York 27, New York Rew York 27, New York Rew York 27, New York Rew York 27, Ne				1.
Professor C. B. diezeno Tadhnische Hoogeschool Niew Laan 76 Delft, Holland  Professor M. A. Biot 1819 Frocessor M. A. Biot 219 Professor R. L. Bisplinghoff Massachusetts Institute of Technology 22 Professor R. L. Bisplinghoff Massachusetts Institute of Technology 23 Professor R. L. Bisplinghoff Massachusetts Institute of Technology 24 Professor R. L. Bisplinghoff Massachusetts Institute of Technology 25 Professor R. L. Bisplinghoff Massachusetts Institute of Technology 26 Professor R. L. Bisplinghoff Massachusetts Institute 27 Professor R. L. Bisplinghoff Massachusetts Institute 28 Professor R. L. Bisplinghoff Massachusetts Institute 29 Professor R. L. Bisplinghoff Massachusetts Institute 29 Professor R. L. Bisplinghoff Massachusetts Massachusetts Massachusetts Massachusetts Dept. of Civil Engineering Columbia University Columbia University New York 27, New York Massachusetts Massachusetts Massachusetts Massachusetts Dept. of Civil Engineering Columbia University Massachusetts Massachusetts Massachusetts Dept. of Civil Engineering Columbia University Columbia University Massachusetts Massachusetts Massachusetts Dept. of Civil Engineering Columbia University Massachusetts Massachusetts Massachusetts Massachusetts Massachusetts Dept. of Civil Engineering Columbia University Massachusetts Massachuset		<b>/- \</b>	Yonkers, New York	(1)
Professor C. B. Blezeno New Laan 76 Delft, Holland  (1) Professor M. A. Biot New Laan 76 Professor M. A. Biot New Sork, New York New York, New York  Der. Hans H. Bleich Dept. of Civil Engineering Columbia University Lafayette, Indiana Professor J. A. Bodey Dept. of Civil Engineering Columbia University Lafayette, Indiana Professor J. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana Professor J. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana Professor J. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1) Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1) Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1) Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1) Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1) Professor D. M. Burmister Dept. of Civil ingineering Columbia University Columbia University Columbia University New York 27, New York  (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University Colum	Bethlehem, rennsylvania	(1)	for American D. T. Omero	
Tachnische Hoogeschool Niewe Laan 76 Delft, Holland Professor M. A. Biot 1819 Broedway New York, New York Professor R. L. Bisplinghoff Missachusetts Institute of Technology Dept. of Aeronautical Engineering Calumbia University New York 27, New York  Professor J. A. Bogdanoff Furdiue University Lafayette, Indiana Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Mechanics Illinois Institute of Technology Technology Center Chicago 16, Illinois Interesting Dr. W. Eckert New York 27, New York  (1)  Dr. W. Eckert New York 27, New York  (1)  Dr. W. Cadambe Assistant Diractor of the National Hysical Laboratory of India New Delhi 12, India	Description of D. Marier			
Niew Laam 76 Delft, Holland (1) Professor M. A. Biot 1819 Broedway New York, New York (1) Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts (1) Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor J. A. Bogdanoff Massachusetts Institute of Technology Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor J. A. Bogdanoff Purdue University Lafayette, Indiana Professor P. W. Bridgenan Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor P. W. Bridgenan Dept. of Civil Engineering Columbia University Cambridge, Massachusetts (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor J. P. Den Hartog Massachusetts Institute of Technology Cambridge 39, Massachusetts (1) Dr. Herbert Deresievicz Dept. of Civil Engineering Columbia University New York 27, New York (1) Dr. C. O. Dobrenwend Bensselaer Tolytechnic Institute Troy, New York (1) Professor T. J. Dolan Dept. of Theoretical and Applied Mechanics University Of Hilinois University Of Technology Technology Center Chicago 16, Illinois Or. W. Eckert Watern Scientific Computing Laboratory New York 27, New York (1) Dr. H. Ekstein Arrour Research Foundation New Delhi Dept. of Technology New York 27, New York (1) Dr. W. Eckert New York 27, New York (1) Dr. H. Ekstein Arrour Research Foundation New Delhi Dept. of Technology New York 27, New York (1) Dr. H. Ekstein Arrour Research Foundation New Delhi Dept. of Technology New York 2				
Professor M. A. Biot 1819 Broadway New York, New York 19 Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Columbia University New York 27, New York 10 Professor J. A. Bogdanoff Furdue University Lafayette, Indiana Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana Columbia University New York 27, New York 10 Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana Columbia University New York 27, New York 11 Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York 12 Indiana Columbia University New York 27, New York 13 Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York 14 Professor B. M. Bridgeman Dept. of Civil Engineering Columbia University Cambridge, Massachusetts 15 Professor D. C. Drucker Brown University New York 27, New York 16 Professor D. C. Drucker Brown University New York 27, New York 17 Professor D. C. Drucker Brown University New York 27, New York 18 Professor D. C. Drucker Brown University New York 27, New York 19 Professor D. C. Drucker Brown University New York 27, New York 10 Professor D. C. Drucker Brown University New York 27, New York 11 Professor D. C. Drucker Brown University New York 27, New York 11 Professor D. C. Drucker Brown University New York 27, New York 11 Professor D. C. Drucker Brown University New York 27, New York 11 Professor D. C. Drucker Brown University New York 27, New York 12 Professor D. C. Drucker Brown University New York 27, New York 12 Professor D. C. Drucker Brown University New York 27, New York 12 Professor D. C. Drucker Brown University New York 27, New York 12 Professor D. C. Drucker Brown University New York 27, New York 14 Professor J. P. Delan Dept. of Civil Engineering New York 27, New York 15 Professor T. J. Delan Dept. of Theoretical and Applied Mechanics Internet Technology Professor D. C. Drucker Brown University New York 27, New York 16 Professor J. P. Delan D			·	(1)
Professor M. A. Biot 1819 Broedway New York, New York  Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Actonautical Engineering Cambridge 39, Massachusetts  Columbia University New York 27, New York  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  (1)  Professor J. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Massachusetts  Harvard University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor J. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor D. C. Drucker Professor D. C. Drucker Providence, Rhode Island  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor D. C. Drucker Providence, Rhode Island  (1)  Professor D. C. Drucker Providence, Rhode Island  Dr. W. Eksert Wateon Scientific Computing Laboratory Chicago If. Illinois Institute of Technology  Dr. W. Eksert New York 27, New York  (1)  Dr. W. Eksert New York 27, New York  Dr. W. Eksert New York 27, New York  Dr. W. Ekseri New York 27, New York  Dr. H. Ekstein Arnour Research Foundation Illinois Institute of Technology  Dr. H. Ekstein Arnour Research Foundation Illinois Institute of Technology  Dr. H. Ekstein Arnour Research Foundation Illinois Institute of Technology		/ <b>5</b> )	orenoble, trance	(4)
Professor M. A. Biot 1819 Breedway New York, New York 1970 Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts 1970 Cambridge 39, Massachusetts 1970 Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts 1970 Professor R. L. Bisplinghoff Massachusetts Derestewicz Dept. of Civil Engineering Columbia University Dept. of Civil Engineering Dept. of Massachusetts Dept. of Civil Engineering Columbia University Dept. of Civil Engineering Dept. of Technology Dept. of Civil Engineering Dept. of Technology Dept. of Civil Engineering Dept. of Technology Technology Center Chicago 16, Illinois Dept. of Mechanics Thyoical Engineering Dept. of Mechanics Thicago 16, Illinois Dept. of Mechanics Thicago 16, Illinois Dept. of Mechanics Thyoical Engineering Dept. of Mechanics Thyoical Engineering Columbia University Dept. of Civil Engineering Columbia University Dept. of Columbia Unive	Serie, vorigin	(4)	Professor I P for Horton	
Cambridge 39, Massachusetts   Cambridge 139, Massachusetts   Cambridge 129, Massachusetts   Cambridge 139, Massachusetts   Cabridge 129, Massachusetts   Cabridge 139, Massachusetts   Cabridge 129, Massachusetts   Cabridge 139, Mas	Professor W. A. Blok			l oev
New York, New York  Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Gambridge 39, Massachusetts  Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University New York 27, New York  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Fhysics Harvard University Cambridge, Massachusetts  Frofessor D. C. O. Dahrenvend Rensselaer Jolytechnic Institute Troy, New York  (1)  Professor T. J. Dolan Dept. of Theoretical and Applied Machanics University of Illinois University of Illinois University of Machanics Illinois Institute of Technology Technology Center Chicago 16, Illinois  Professor D. C. Drucker Brown University Providence, Rhode Island  Dr. W. Eckert Watson Scientific Computing Laboratory New York 27, New York  (1)  Dr. W. Eckert New York 27, New York  Dr. Herbert Deresiewicz Dept. of Civil Engineering Columbia University Professor I. J. Dolan Dept. of Theoretical and Applied Machanics University of Illinois University of Illino				
Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts  Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University Lafayette, Indiana  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor J. J. Dolan Dept. of Civil Engineering University of Illinois University of Illinois University of Illinois University of Illinois Lept. of Mechanics Illinois Institute of Technology Technology Center Chicago 16, Illinois Linding Computing Laboratory Columbia University New York 27, New York  (1)  Dr. W. Cadambe Assistant Director of the National Lhysical Leboratory of India New Dalhi 12, India  Dr. Hertert Dept. of Civil Engineering Columbia University Tolumbia University Thew York 27, New York  (1)  Dr. C. O. Debrewend Rensseleer Tolytechnic Institute Troy, New York (1)  Professor J. J. Dolan Dept. of Theoretical and Applied Mechanics University Theory fork (1)  Professor J. J. Dolan Dept. of Mechanics Illinois Linstitute of Technology Technology Center Chicago 16, Illinois Columbia University Theoretical and Applied Mechanics University Theoretical and Applied Mechanics University Theoretical and Applied Mechanics Thouse Institute Troy, New York (1)  Professor J. A. Bogdanoff Professor J. A. Bogdanoff Professor J. A. Bogdanoff Theoretical and Applied Mechanics Theoretical and Applied Mechanics Thinois Institute of Technology Technology Theoretical and Applied Mechanics Theoretical and Applied Mechanics Theoretical and Applied Mechanics Theoretical and Appli	· · · · · · · · · · · · · · · · · · ·	(1)	Campinate // / / managarane / / /	,-,
Professor R. L. Bisplinghoff Massachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts  Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University Rew York 27, New York  Professor J. A. Bogdanoff Purdue University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Mechanics Illinois Institute of Technology Technology Center Chicago 16, Illinois Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor D. M. Burmister Dept. of Mechanics Illinois Institute of Technology Technology Center Chicago 16, Illinois Cambridge, Massachusetts  (1)  Professor D. C. Drucker Thom University Providence, Finde Island Calumbia University New York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor D. C. Drucker Thom University Providence, Finde Island Calumbia University New York 27, New York  (1)  Dr. W. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  India Institute of Civil Engineering Columbia University New York 27, New York  Call Engineering Columbia University Theoretical and Applied Mechanics University Theoretical and Applied Professor Log Mechanics Illinois Institute of Technology  Technology Center Chicago 16, Illinois Calumbia University New York 27, New York Call West 112th Street New York 27, New York Call Engineering Columbia University New York 27, New York Call Engineering Columbia University Cambridge Theoretical and Applied Professor T. J. Dolan Dept. of Theoretical and Applied Professor Illinois Chicago 16, Illinois Chicago 16, Illinois Calumbia University Call Engineering Columbia University Cambridge Theoretical and Applied Professor I. C. O. Dolan Call Call Call Call Call Call Call Call	Ham Zork's How Tork	(1)	Dr. Harbert Deresiewicz	
Massachusetts Institute of Technology Dept. of Aeronautical Engineering Cambridge 39, Massachusetts  Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University New York 27, New York  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor F. W. Bridgeman Dept. of Mechanics Chicago 16, Illinois Chicago 16, Illinoi	Professon R. L. Rienlinghoff			
Dept. of Aeronautical Engineering Cambridge 39, Massachusetts  Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York  Professor F. W. Bridgeman Dept. of Civil Engineering Columbia University New York  Professor F. W. Bridgeman Dept. of Civil Engineering Columbia University New York  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Professor D. C. Drucker Brown University Providence, Rhode Island  (1)  Dr. W. Eckert Watson Scientific Computing Laboratory New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dr. W. Eckert New York 27, New York  Canbridge  Dept. of Theoretical and Applied Nechanics  Calumbia University Dept. of Mechanics  Calumbia University Canbridge  Dept. of Mechanics  Calumbia University Canbridge  Dept. of Mechanics  Calumbia University Canbridge  Dept. of Mechanics  Calumbia		A 097		
Cambridge 39, Massachusetts  Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Fhysics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Professor D. C. Drucker Enow University Providence, Rhode Island  Professor D. M. Eckert Watson Scientific Computing Laboratory New York 27, New York  (1)  Dr. W. Eckert New York 27, New York  Dr. W. Ekstein Armour Research Foundation Illinois Institute of Technology  All India  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology  All India  The Stript Columbia University India  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology  All India  The India India Institute of Technology  All India  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology		<b>~6√</b>		
Dr. Hans H. Bleich Dept. of Civil Engineering Columbia University New York 27, New York  Professor J. A. Begdanoff Furdue University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University Lafayette, Indiana  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Fhysics Harvard University Cambridge, Massachusatts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Fhysics Harvard University Cambridge, Massachusatts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Dr. W. Eckert Watson Scientific Computing Laboratory New York 27, New York  (1)  Dr. H. Ekstein Allow Englowed Allow Institute Troy, New York (1)  Professor T. J. Dolan Rechanics Illinois Institute Troy, New York (1)  Professor T. J. Dolan Rechanics Illinois Nechanics Illinois (1)  Professor Lleyd Donnell Dept. of Mechanics Illinois Institute of Technology	Cambridge 39. Massachusatts	(4)		(1)
Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor F. W. Bridgeman Dept. of Fhysics Harvard University Cambridge, Massachusetts  Dept. of Civil ingineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Hysical Laboratory of India New Delhi 12, India  Remsselaer Tolytechnic Institute Troy, New York  Professor T. J. Dolan Dept. of Theoretical and Applied Mechanics University of Illinois Professor Lloyd Donnell Dept. of Mechanics University of Illinois Institute of Technology Technology Center Chicago 16, Illinois (1)  Dr. W. Eckert Watson Scientific Computing Laboratory New York 27, New York  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology  (1)		, cm ,		
Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana Lafayette, Indiana  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  Cambridge, Massachusetts  Dept. of Fhysics Harvard University Cambridge, Massachusetts  Dept. of Civil Engineering Columbia University Canbridge, Massachusetts  Dept. of Civil Engineering Columbia University Canbridge, Massachusetts  Dept. of Fhysics Harvard University Canbridge, Massachusetts  Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  Dept. of Fhysics Harvard University Canbridge, Massachusetts  Dept. of Civil Engineering Columbia University Columbia University New York 27, New York  Columbia University New York 27, New York  Dr. W. Eckert New York 27, New York  Dr. W. Eckert New York 27, New York  Dr. H. Ekstein Armour Research Foundation Hysical Laboratory of India New Delhi 12, India  (1)  Professor T. J. Dolan Dept. of Theoretical and Applied Mechanics University of Illinois Webanics University of Illinois University of Illinois Webanics University of Illinois Webanics University of Illinois Webanics Illinois Institute of Technology  Professor Lloyd Donnell Dept. of Mechanics Illinois Institute of Technology  Professor Lloyd Donnell Dept. of Mechanics  Illinois Institute of Technology  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology	Dr. Hans H. Bleich		Dr. C. O. Dohrenwend	
Columbia University New York 27, New York  Professor J. A. Bogdanoff Furdue University Lafayette, Indiana  Infoyen York  Infoyence York  Infoyen York  Infoyence York  Infoyen			Rensselaer Folytechnic Institute	
New York 27, New York  Frofessor J. A. Bogdanoff Furdue University Lafayette, Indiana  Frofessor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  Professor F. W. Bridgeman Dept. of Fhysics Cambridge, Massachusetts  Frofessor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Professor F. W. Bridgeman Dept. of Fhysics Cambridge, Massachusetts  Frofessor D. C. Drucker Brown University Providence, Rhode Island  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Professor D. M. Eckert New York 27, New York  Professor D. M. Eckert New York 27, New York  Professor D. M. Eckert New York 27, New York  Professor D. M. Eckert New York 27, New York  Professor D. M. Eckert New York 27, New York  Professor D. M. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York  Professor D. C. Drucker Dr. W. Eckert New York 27, New York				(1)
Professor J. A. Bogdanoff Furdue University Lafayette, Indiana (1) Whenhality of Illinois Urbana, Illinois (1) Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York (1) Professor F. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York (1) Dr. V. Cadambe Assistant Director of the National Physical Leboratory of India New Delhi 12, India (1)  Professor T. J. Dolan Dept. of Theoretical and Applied Mechanics University of Illinois University of Illinois (1) Professor fleyd Donnell Dept. of Mechanics (1) Professor fleyd Donnell Opt. of Mechanics (1) Professor fleyd Donnell Dept. of Fleyd Technology Tec		(1)	• ,	
Furdue University Lafayette, Indiana  (1) University of Illinois Urbans, Illinois (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  (1) Illinois Institute of Technology Technology Center Chicago 16, Illinois (1)  Professor D. C. Drucker  Brown University Cambridge, Massachusetts  (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1) Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  (1) Mechanics University of Illinois (1)  Professor Lloyd Donnell Dept. of Mechanics (1)  Professor D. C. Drucker Dr. W. Eckert Watson Scientific Computing Laboratory (1)  Dr. W. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  (1) Illinois Institute of Technology	•	<b>,</b> - ,	Professor T. J. Dolan	
Furdue University Lafayette, Indiana  (1)  Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  Professor F. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1)  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  (1)  Mechanics University of Illinois (1)  Professor Lloyd Donnell Dept. of Mechanics (1)  Professor Lloyd Donnell Dept. of Mechanics (1)  Professor Lloyd Donnell Dept. of Mechanics (1)  Professor D. C. Drucker Brown University Providence, Rhode Island (1)  Dr. W. Eckert Watson Scientific Computing Laboratory (1)  Dr. H. Ekstein Arnour Research Foundation Illinois Institute of Technology  Dr. H. Ekstein Arnour Research Foundation Illinois Institute of Technology	Professor J. A. Bogdanoff		Dept. of Theoretical and Applied	
Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  Professor F. W. Bridgeman Dept. of Mechanics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Leboratory of India New Delhi 12, India  (1)  Professor B. A. Boley Professor fleyd Donnell Dept. of Mechanics Illinois Institute of Technology Professor fleyd Donnell Dept. of Mechanics Illinois Institute of Technology Illinois Institute of Technology  Professor fleyd Donnell Dept. of Mechanics Illinois Institute of Technology Illinois Institute of Technology Illinois Institute of Technology				
Professor B. A. Boley Dept. of Civil Engineering Columbia University New York 27, New York  Professor P. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  On W. Codambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Professor Ileyd Donnell Dept. of Mechanics Illinois Institute of Technology Technology Center Chicago 16, Illinois Illinois Professor D. C. Drucker Brown University Providence, Rhode Island (1)  Professor D. M. Burmister Dr. W. Eckert Watson Scientific Computing Laboratory New York 27, New York (1)  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Professor Ileyd Donnell Dept. of Mechanics Illinois Institute of Technology	Lafayette, Indiana	(1)		4.
Dept. of Civil Engineering Columbia University New York 27, New York  Professor F. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Professor India Professor Levi Mechanics Illinois Institute of Technology Technology Center Chicago 16, Illinois (1)  Professor D. C. Drucker Brown University Providence, Rhode Island (1)  Dr. W. Eckert Watson Scientific Computing Laboratory 612 West 116th Street New York 27, New York (1)  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology			Urbans, Illinois	(1)
Columbia University New York 27, New York  New York 27, New York  (1)  Professor P. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Leboratory of India New Delhi 12, India  Perfessor (1)  Dept. of Mechanics Illinois Institute of Technology Technology Center Chicago 16, Illinois (1)  Professor D. C. Drucker Brown University Providence, Rhode Island (1)  Dr. W. Eckert Watson Scientific Computing Laboratory New York 27, New York (1)  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology  (1)				
New York 27, New York  Professor P. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  (1)  Illinois Institute of Technology Technology Center Chicago 16, Illinois (1)  Professor D. C. Drucker Brown University Providence, Rhode Island (1)  Professor D. M. Burmister Dr. W. Eckert Watson Scientific Computing Laboratory (1)  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  (1)  Illinois Institute of Technology (1)	Dept. of Civil Engineering			
Professor F. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Technology Center Chicago 16, Illinois Professor D. C. Drucker Providence, Rhode Island (1)  Dr. W. Eckert Watson Scientific Computing Laboratory New York 27, New York (1)  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology				
Professor P. W. Bridgeman Dept. of Physics Harvard University Cambridge, Massachusetts  Professor D. C. Drucker Brown University Providence, Rhode Island  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Chicago 16, Illinois  Professor D. C. Drucker Brown University Providence, Rhode Island  (1)  Dr. W. Eckert Watson Scientific Computing Laboratory 612 West 116th Street New York 27, New York  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology	New York 27, New York	(1)		
Dept. of Physics Harvard University Cambridge, Massachusetts  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Professor D. C. Drucker Brown University Providence, Rhode Island (1)  Dr. W. Eckert Watson Scientific Computing Laboratory (1) 612 West 116th Street New York 27, New York (1)  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology			Technology Center	/s \
Harvard University Cambridge, Massachusetts  (1) Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Professor D. C. Drucker Brown University Providence, Rhode Island (1)  Dr. W. Eckert Watson Scientific Computing Laboratory National Watson Scientific Computing Laboratory New York 27, New York  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology			Chicago lo, Illinois	(1)
Cambridge, Massachusetts  (1) Brown University Providence, Rhode Island  (1)  Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  (1) Computing Laboratory  (1) Matson Scientific Computing Laboratory  (2) Mest 116th Street New York 27, New York  (3) Dr. V. Cadambe  Assistant Director of the National Physical Laboratory of India New Delhi 12, India  (1) Brown University Providence, Rhode Island (1)  Dr. W. Eckert National Street New York 27, New York  (1)  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology			Brade and D. G. Demasterer	
Professor D. M. Burmister  Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Providence, Rhode Island (1)  Dr. W. Eckert Watson Scientific Computing Laboratory 612 West 116th Street New York 27, New York (1)  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology		/= 1		
Professor D. M. Burmister Dept. of Civil Engineering Columbia University New York 27, New York  Or. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Or. W. Eckert Watson Scientific Computing Laboratory Matson Scientific Computing Laboratory Watson Scientific Computing Laboratory Watson Scientific Computing Laboratory Watson Scientific Computing Laboratory Matson Scientific Computing Laboratory Matson Scientific Computing Laboratory Matson Scientific Computing Laboratory New York 27, New York  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology	Cambridge, Massachusetts	(1)		(9)
Dept. of Civil Engineering Columbia University New York 27, New York  Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Proceeding Dr. W. Eckert Watson Scientific Computing Laboratory 612 West 116th Street New York 27, New York  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology	Bandan and Bandan Later		Providence; whode istand	( - )
Columbia University  New York 27, New York  Dr. V. Cadambe  Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Watson Scientific Computing Laboratory 612 West 116th Street New York 27, New York  Dr. H. Ekstein Armour Research Foundation Illinois Institute of Technology			Da W Taleant	
New York 27, New York  Or. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  (1)  612 West 116th Street New York 27, New York  Or. H. Ekstein Armour Research Foundation Illinois Institute of Technology				n t Arro
New York 27, New York (1)  Dr. V. Cadambe  Assistant Director of the National Physical Laboratory of India Armour Research Foundation  New Delhi 12, India (1) Illinois Institute of Technology		/9 \		a 004 y
Dr. V. Cadambe Assistant Director of the National Physical Laboratory of India New Delhi 12, India  Or. H. Ekstein Armour Research Foundation Illinois Institute of Technology	New IOTE 4/4 New IOTE	(1)		(1)
Assistant Director of the National Dr. H. Ekstein  Physical Laboratory of India Armour Research Foundation  New Delhi 12, India (1) Illinois Institute of Technology	De II Ocharba		HON TOTY #14 HOM TOTY	(-/
Physical Leboratory of India Armour Research Foundation New Delhi 12, India (1) Illinois Institute of Technology			Dr. H. Ekstein	
New Delhi 12, India (1) Illinois Institute of Technology				
		/a \		
	wew batur is tudio	\ <b></b> <i>j</i>		(1)

ANTO TO THE PARTY OF THE PARTY		THE THE PARTY OF T	<u> </u>
Tu advantus. I d base see		Por T P O LA	
Engineering Library		Dr. L. E. Goodman	
Columbia University		Dept. of Civil Engineering	
New York 27, New York	(1)	University of Illinois	
		Urbana, Illinois	(1)
Professor E. L. Erikaen		,	, ,
University of Michigan		Dr. R. J. Hansen	
Ann Arbor, Michigan	(1)	Massachusetts Institute of Technol	0.027
Mill Mroor's amourgan	(1)		
		Dept. of Civil & Sanitary Engineer	Jug
Professor A. C. Eringen		Cambridge 39, Massachusetts	(1)
Illinois Institute of Technology			
Tachnology Center		Professor R. M. Hermes	
Chicago 16, Illinois	(1)	University of Santa Clara	
	• • •	Santa Clara, California	(1)
Dr. W. L. Esmeijer			ν-,
Technische Hoogeschool		Professor G. Herrmann	
Niewe Laan 76	1-1	Dept. of Civil Engineering	
Delft, Holland	(1)	Columbia University	10.1
		New York 27, New York	(1)
Professor A. M. Freudenthal			
Dept. of Civil Engineering		Professor M. Hetenyl	
Columbia University		Northwestern University	
New York 27, New York	(2.)	The Technological Institute	
NOW TOTA BY I HOM TOTA	(6) /	Evanston, Illinois	(1)
Francis Balad		MAGUS fout TTTTHATA	', aL /
Professor B. Fried	1		
Washington State College		Professor I. J. Higgins	
Fullman, Washington	(1)	Dept. of Electrical Engineering	
		University of Wisconsin	
Professor K. O. Friedrichs		Madison 6, Wisconsin	(1)
New York University		,	
Washington Square		Dr. N. J. Hoff, Head	
New York, New York	(1)	Dept. of Aeronautical Engineering	
HEM SATUR HOM SATU	\ <b>-</b> /	& Applied Mechanics	
Smadage on M. M. Sharabil		Selection in the blanks of Breakling	
Professor M. M. Freeht		Polytechnia Institute of Brooklyn	
Illinois Institute of Technology		99 Livingston Street	191
Technology Center		Brooklyn 2, New York	(1)
Chicago 16, Illinois	(1)		
•		Frofessor M. B. Hogan	
Professor J. M. Garrelts		University of Utah	
Dept. of Civil Engineering		Selt lake City, Utah	(1)
Columbia University		FETT TO ON OF A A A A A A A A A A A A A A A A A A	,
	(1)	Professor D. L. Holl	
New York 27, New York	(4)		
		Iowa State College	19 \
Dean J. A. Goff		Ames, Iowa	(1)
University of Fennsylvania			
Philadelphia, Pennsylvania	(1)	Dr. J. H. Hollomon	
•		General Electric Research Labs.	
Mr. Martin Goland		1 River Road	
Midwest Research Institute		Schenectady, New York	(1)
		Mustice sary them total	/
4049 Pennsylvania Avenue	/ <b>1</b> \	Marie II U Uzammanan	
Kansas City 2, Missouri	(1)	Dr. W. H. Hoppmann	
		Dept. of Applied Machanics	
Dr. J. N. Goodier		John Hopkins University	1- 1
Dept. of Mechanical Engineering		Baltimore, Maryland	(l)
Stanford University			
Stanford, California			

### Contractors and Other Investigators Actively Engaged in Related Research (cont.)

Institut de Mathematiqués		Description of the Comment	
Université		Professor C. T. G. Looney	
post. fah 55		Dept. of Civil Engineering	
Skopje, Yugoslavia	(1)	Yale University	/5.1
proble; infertaria	(1)	New Haven, Commetticut	(1)
Professor L. S. Jacobsen		Dr. J. L. Lubkin	
Dept. of Mechanical Engineering		Midwest Research Institute	
Stanford University			
	(1)	4049 Pennsylvania Avenue	(4.)
Stanford, California	(1)	Kansas City 2, Missouri	(1)
Professor Eruge G. Jahnston		Professor J. F. Ladloff	
University of Michigan		School of Aeromautics	
Ann Arbor, Michigan	(1)	New York University	
Giff OF DAY & LIMENIA POST	(34)	New York 53, New York	(1)
Professor K. Motter		then form 234 Hen form	(+)
Stanford University		Professor J. N. Macduff	
Stanfard, California	(1)	Renseelaer Folytechnic Institute	
HADNIX BUT IT A BUTTA AN INTO	\ <del>_</del>	Troy, New York	(1)
Professor W. J. Krefeld		Troy , New 101%	<b>\_</b> <i>)</i>
Dept. of Civil Engineering		Sunfacean A U Nachmann	
Columbia University		Professor C. W. MacGregor	
Kow York 27, New York	(1)	University of Pennsylvania	/ <b>a</b> \$
MOM TOLK TI WAN TALK	(4)	Philadelphia, Punnsylvania	(1)
Professor B. J. Lacan	÷	Professor Lawrence E. Malvern	
Dept. of Materials Engineering		Dept. of Mathematics	
University of Minnesota		Carnegia Intlitute of Technology	
Minneapolis, Minnesota	(1)	Pitteburgh 13, Fennsylvania	(1)
Immedia postala i i inicio o on	1-7	* # 0 0 D G G EN # 2 4 * O MIND \$ # + CHIE	(.5 /
Dr. E. H. Lee		Dr. J. H. Marchant	
Division of Applied Mathematics		Brown University	
Ergin University		Providence, Rhode Island	(1)
Providence, Shade Island	(1)	reorgany resource records	,-,
	1-/	Professor J. Marin	
Professor George Lee		Pennsylvania State College	
Rensselser Polytechnic Institute		State College, Pennsylvania	(1)
Troy, New Yerk	(1)	Sector downers to be to be to be to be	(-/
as 45 a most a constant	\ <b>-</b> /	Dr. W. P. Mason	
Professor J. M. Lessells		Bell Telephone Laboratories	
Massachusetts Institute of Technol.	<del>00</del> ∇	Mirray Hill, Key Jersey	(1)
Cambridge 39, Massachusetts	(1)	THE COURT NAME OF THE POPULATION	,
CONTRACTOR NAME OF THE PROPERTY OF THE PROPERT	\ <del>-</del> /	Professor R. D. Mindlin	
Mbrary, Engineering Foundation		Dept. of Civil Engineering	
29 West 39th Street		Columbia University	
New York, New York	(I)	632 West 125th Street	
HOM TOTAL HOM THEY	\ <del>-</del> /	New York 27, New York	(15)
Professor Faul lieber		MOM TATE WIND TATE	(エフ)
Dept. of Engineering		Dr. A. Nadai	
Rensselaer Polytechnic Institute			
	(1)	136 Cherry Valley Road	(1)
Troy, New York	(1)	Pittsburgh 21, Ponnsylvania	(1)
Dr. Hau Lo		Professor Paul M. Naghdi	
Purdue University		Dept. of Engineering Mechanica	
Lafayette, Indiana	(1)	University of Michigan	
and the contraction of the contr	\ <del>-</del> /	Ann Arbor, Michigan	(1)
		will we have a literate Rest.	(±)

Contractors and Other Investigator	e Activ	ely Engaged in Related Research (con	<u>t.)</u>
Professor N. M. Newmark		Dr. S. Raymor	
Dept. of Civil Engineering		Armour Research Foundation	
University of Illinois		Illinois Institute of Technology	
Urbana, Illinois	(1)	Chicago 16, Illinois	(1)
ordana i illinois	<b>,</b> ± /	curoago to, illinois	(T)
Professor Jesse Crmondroyd		Professor E. Reissner	
University of Michigen		Dept. of Mathematics	
Ann Arbor, Michigan	(1)	Massachusetts Institute of Technol	A FV
imm im age à implimedent	1 🏎 /	Combridge 39, Massachusatts	(1)
Dr. W. Osgood			(-/
Illinois Institute of Teehnology		Professor H. Reissner	
Technology Center		Polyteehnie Institute of Brocklyn	
Chicago 16, Illinois	(1)	99 Livingston Street	
autabla ial millioro	\ <del>-</del> /	Brooklyn 2, New York	(1)
Dr. George B. Pegram			, - ,
Committee en Gevernment Aided Rese	dera	Dr. Kenneth Robinson	
313 Low Memorial Library	•	National Bureau of Standards	
Columbia University		Washington, D.C.	(1)
New York 27, New York	(1)	Hamman Protection of the Control of	ν – ν
HOM TON DIA TON	14/	Professor M. A. Sadowsky	
Dr. R. P. Paterson		Diings Institute of Technology	
Director, Applied Physics Division	١.	Technology Center	
Sandia laboratory	t i	Chicago 16, Illinois	(1)
Albuquerque, New Mexico	(1)	errange and memorial	\ <del>-</del> /
viramination in the towards	\ <del>-</del> /	Professor M. J. Salvadori	
Mr. R. E. Peterson		Dept. of Civil Engineering	
. Westinghouse Research Laboratories		Columbia University	
Esst Pittsburgh, Pennsylvania	(1)	New York 27, New York	(1)
SSOA * RAAB BAT Rit 1 10 HH G 2 T 4 BHS 17	\ <b>&amp;</b> /	NOW MOSE WITH MOSE	\ <b>-</b> /
Dr. A. Hillips		Dr. F. S. Sagu	
School of Engineering		Polytechnic Institute of Brocklyn	
Stanford University		99 Myingston Street	
Stanford, California	(1)	Brooklyn 2, New Yark	(1)
a Section of a community of the section	\~ <i>/</i>		• •
Professor Cerald Pickett		Dr. Daniel T. Sigley	
Dept. of Mechanics		Applied Physics Laboratory	
University of Wissensin		John Hopkins University	
Madison 6, Wisconsin	(1)	8621 Georgia Avenue	
•	. ,	Silver Spring, Maryland	(1)
Dr. H. Poritsky			
Ceneral Electric Research Labs.		Dr. C. B. Smith	
Schenectedy, New York	(1)	Department of Mathematics	
• •		Walker Hall	
Dr. W. Frager		University of Florida	, - \
Graduate Division of Applied Mathe	Estics	Gainesville, Florida	(1)
Brown University			
Providence, Rhode Island	(1)	Professor C. R. Soderberg	
		Massachusetts Institute of Technol	.၀ဠာ ျ
RAND Corporation		Cambridge 39, Massachusetts	(1)
1500 4th Street			
Santa Monica, California	, .	Professor R. V. Southwell	
Attn: Dr. D. L. Judd	(1)	Imperial College of Science and	
		Technology	
		South Kensington London S.W. 7. England	(1)
		LANGON S.W. 7. ENGLANG	[ ] ]

Contractors and Other Investigators	AND THE LAND		سنابك
Professor E. Sternberg		Professor E. Voltarra	
Illinois Institute of Technology		Rensselaer Polytechnic Institute	
Technology Center		Troy, New York	(1)
Chicago 16, Illinois	(1)	· · · · · · · · · · · · · · · · ·	· - /
		Mr. A. M. Wahl	
Professor J. J. Stoker		Westinghouse Research Laboratories	8
New York University		East Pittsburgh, Pennsylvania	(1)
Washington Square			, ,
New York, New York	(1)	Professor C. T. Weng	
		Dept. of Aeronautical Engineering	
Mr. R. A. Sykes		New York University	
Bell Telephone Laboratories		University Heights, Bronx	
Murray Hill, New Jersey	(1)	New York, New York	(1)
	, - ,	HOW LOAN HOW LOAN	\ <del>-</del> /
Professor P. S. Symonds		Dr. R. L. Wegel	
Brown University		RFD 2	
Providence, Rhode Island	(1)	Peekskill, New York	(1)
,	, ,		,
Professor J. L. Synge		Professor E. E. Weibel	
Dublin Institute for Advanced Studie	38	University of Colorado	
School of Theoretical Physics		Boulder, Colorado	(1)
64-65 Merrion Equare			
Bublin, Ireland	(1)	Dr. Alexander Weinstein	
·	, ,	Institute of Applied Mathematics	
Professor I. K. Telehmann		University of Maryland	
Dept. of Aeronautical Engineering		College Pork, Maryland	(1)
New York University		Howard and Total Control of the Control	, - ,
University Heights, Bronz		Professor Dana Young	
New York, New York	(1)	Yale University	
	,,	Hew Maven, Commecticut	(1)
Professor S. F. Timoshenko		in the the transfer of the tra	1-1
School of Engineering			
Stanford University			
Stanford, California	(1)		
	,		
Dr. C. A. Trusedell			
Graduate Institute for Applied Mathe	reatics		
Indiana University			
Bloomington, Indiana	(1)		
<del>-</del>			
Professor Karl S. Van Dyke			
Department of Physics			
Scott Laboratory			
desleyan University			
desleyan University	(1)		
wasleynn University Middletown, Connecticut	(1)		
Wesleyan University Middletown, Connecticut Or. I. Vigness	(1)		
Wasleyan University Middletown, Connecticut Or. I. Vigness Naval Research Laboratory	(1)		
Wasleyan University Middletown, Connecticut  Or. I. Vigness	(1)		

(1)

Dr. Leonardo Villena Gran Via J. Antonio 6 Madrid, Spain